WHEN SPACE MEETS AGRICULTURE

14-15 November 2016 | Matera, Italy

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OPTICAL REMOTE SENSING FOR THE RETRIEVING OF CROP BIOPHYSICAL PROPERTIES OF AGRONOMIC INTEREST

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imaa istituto di metodologie per l'analisi ambientale

REGIONE BASILICATA

nereus network of european regions using space technologies

in collaboration with

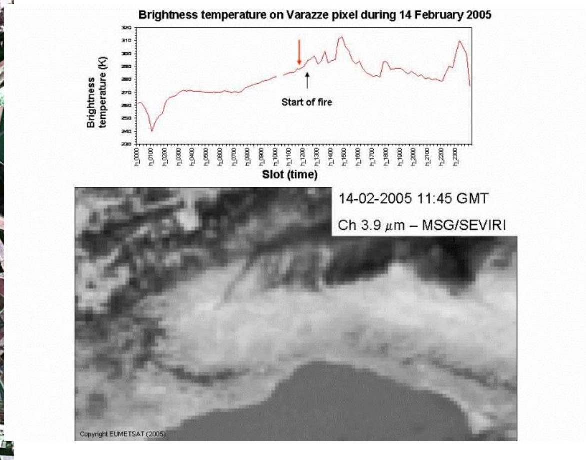
T e R N

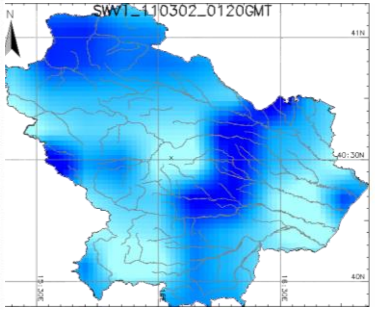
and the support of

copa cogeca european farmers european agri-cooperatives

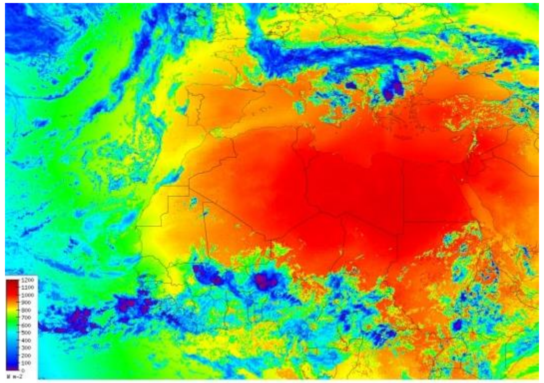
ERIAFF Network European Regions for Innovation in Agriculture, Food and Forestry

CNR IMAA research activities for Agri sector

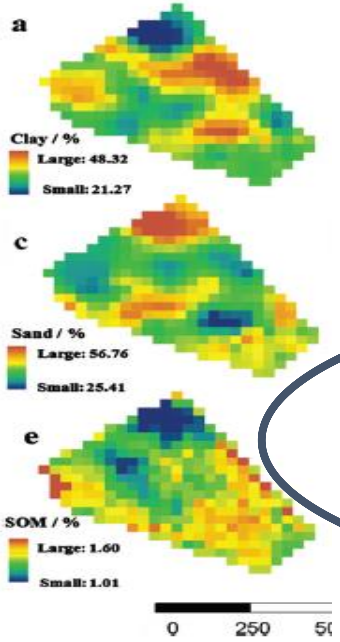




Multi-temporal EO imagery analysis for natural hazards monitoring and Early Warning (floods, fires, etc.)



Agro-meteorological variables estimation by weather satellites data analysis



Retrieval of biophysical variables of agronomic interest by optical remote sensing techniques

Development and optimization of algorithms and methods for soil and crop biophysical variables estimation using satellite hyperspectral data *(SAP4PRISMA project - ASI)*

Soil components

EO Products	Description	Unit	EO product maturity level	Notes
CLAY	Percentage of clay in the first 30 cm of soil	%	medium	limited to mechanically prepared bare ground
SILT	Percentage of silt in the first 30 cm of soil	%	medium	
SAND	Percentage of sand in the first 30 cm of soil	%	medium	
SOC	Percentage of organic carbon in the first 30 cm of soil	%	low	

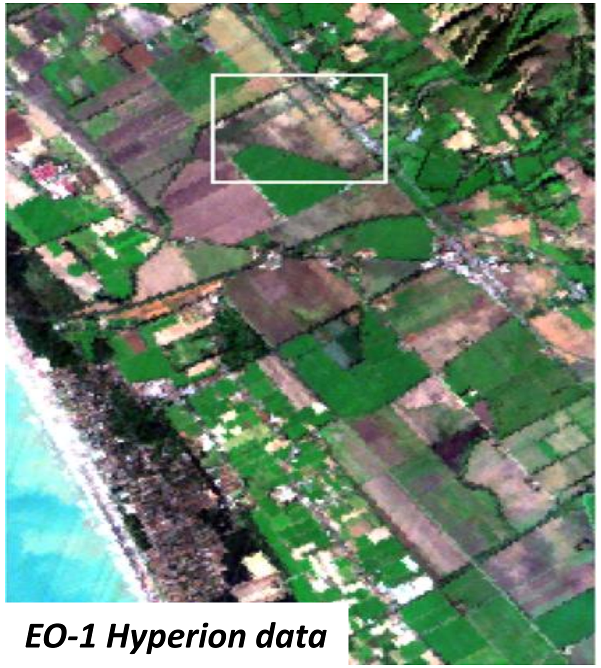
Vegetation components

EO Products	Description	Unit	EO product maturity level	Notes
LAI	Leaf Area Index	-	high	limited to herbaceous crops
Cab	Chlorophyll a and b Content of in leaves per unit of area	mg cm^{-2}	high	
FPAR	Fraction of photosynthetically active radiation absorbed by vegetation cover	-	high	

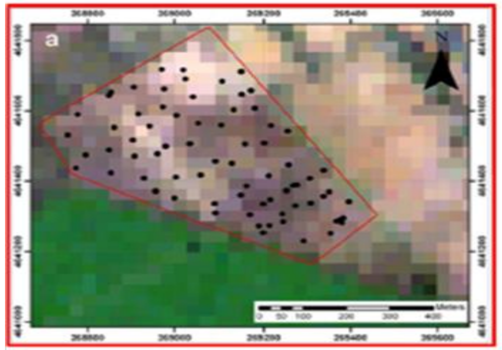
Agricultural components

EO Products	Description	Unit	EO product maturity level	Notes
YLD	Crop production	t ha^{-1}	low	limited to a cereal crop to be defined
QN	Content of nitrogen in the aboveground biomass	%	low	
GN	Nitrogen content in grain	%	low	
Nres	nitrate nitrogen (NO3-N-) in the soil at the end of crop cycle	kg ha^{-1}	low	

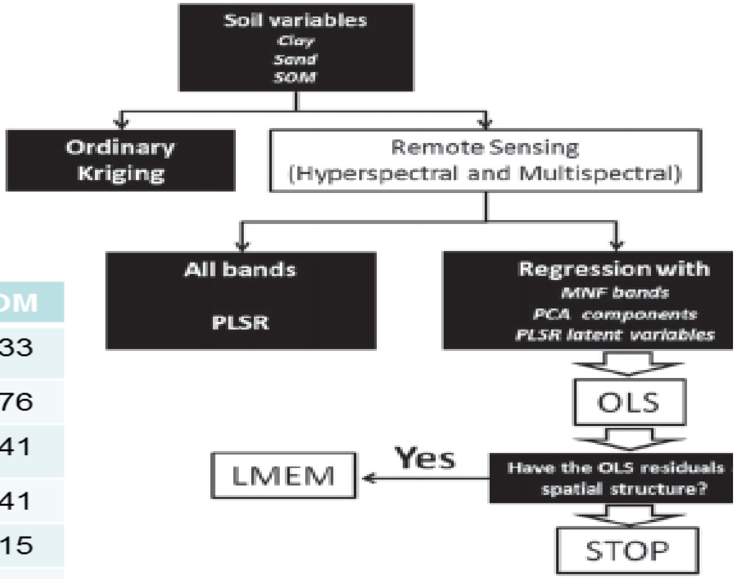
Soil variables estimation: texture (%clay, silt, sand) + Organic Matter (SOM)

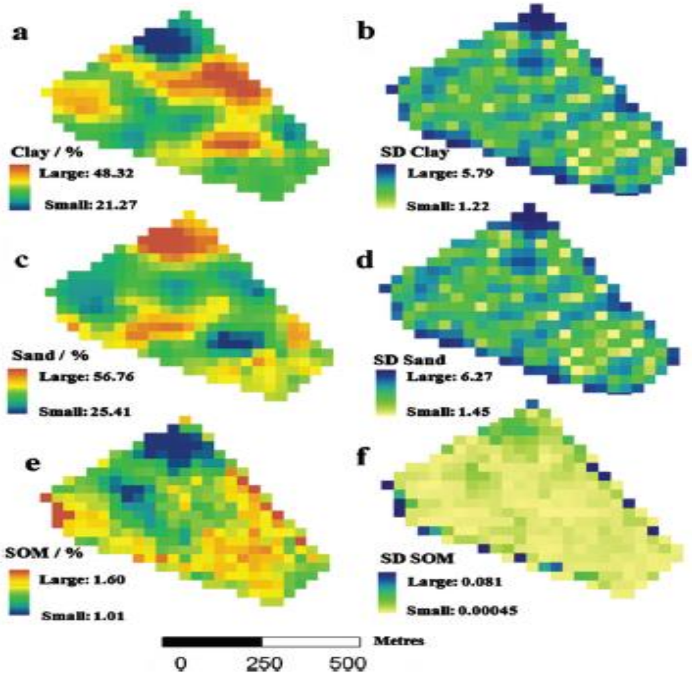


EO-1 Hyperion data



Field	Variable	n	Min / %	Max / %	Mean / %	σ	CV	Skewness
B041	Clay	72	18.37	49.61	37.91	6.82	0.18	−0.37
	Sand	72	23.10	60.43	36.55	7.31	0.20	0.95
	SOM	72	1.07	2.67	1.69	0.44	0.26	0.64

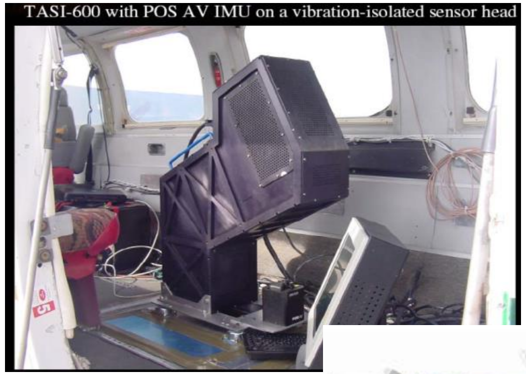


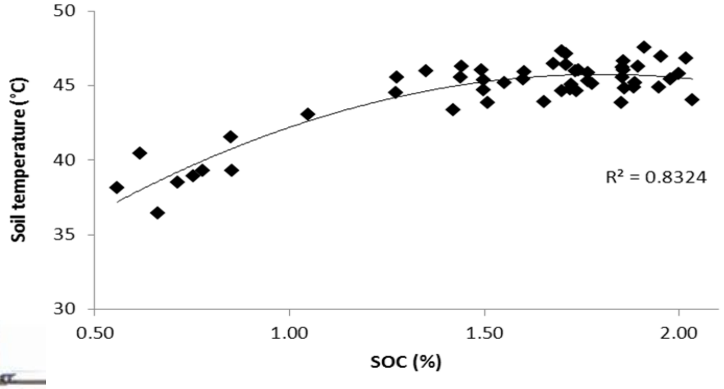


		Clay	Sand	SOM
OK Ordinary K.	RMSE	4.46	5.18	0.33
	RIPQ	2.29	1.69	1.76
PLSR Partial least square regr.	RMSE	5.95	6.69	0.41
	RIPQ	1.64	1.31	1.41
LMEM Linear mixed effect model	RMSE	4.07	4.90	0.15
	RIPQ	2.40	1.79	3.87

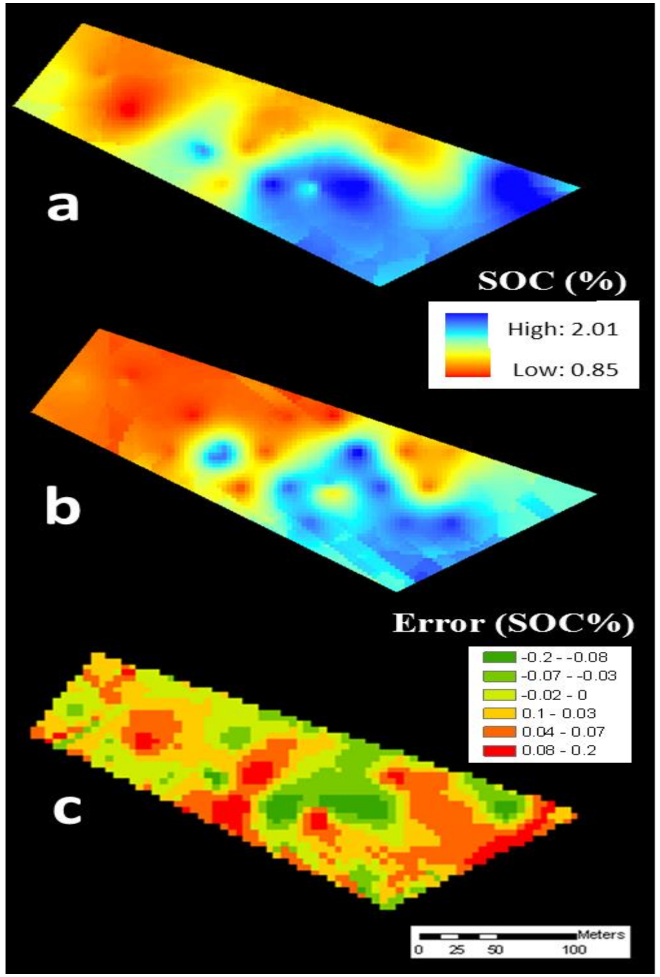
F. Castaldi, R. Casa, A. Castrignanò, S.Pascucci, A. Palombo and S. Pignatti *«Estimation of soil properties at the field scale from satellite data: a comparison between spatial and non-spatial techniques»* ESJ, Volume 65, Issue 6, pages 842–851, November 2014

Soil variables estimation: Soil Organic Carbon (SOC) estimation using TASI-600 airborne multispectral data





T (°C) estimated from TASI-600 data vs
actual soil organic content in the sample points



Soil Variable	Datum	Technique	No. of PLSR factors	R^2	RMSE	RPD	RPIQ
Clay	Emissivity	PLSR	4	0.27	5.85	1.18	0.99
	MNF	Cubist		0.42	5.15	1.34	1.13
Sand	Emissivity	PLSR	2	0.10	4.77	1.10	1.50
	MNF	Cubist		0.15	4.61	1.14	1.55
SOC	Emissivity	PLSR	2	0.24	0.31	1.18	1.51
	MNF	Cubist		0.53	0.26	1.46	1.96

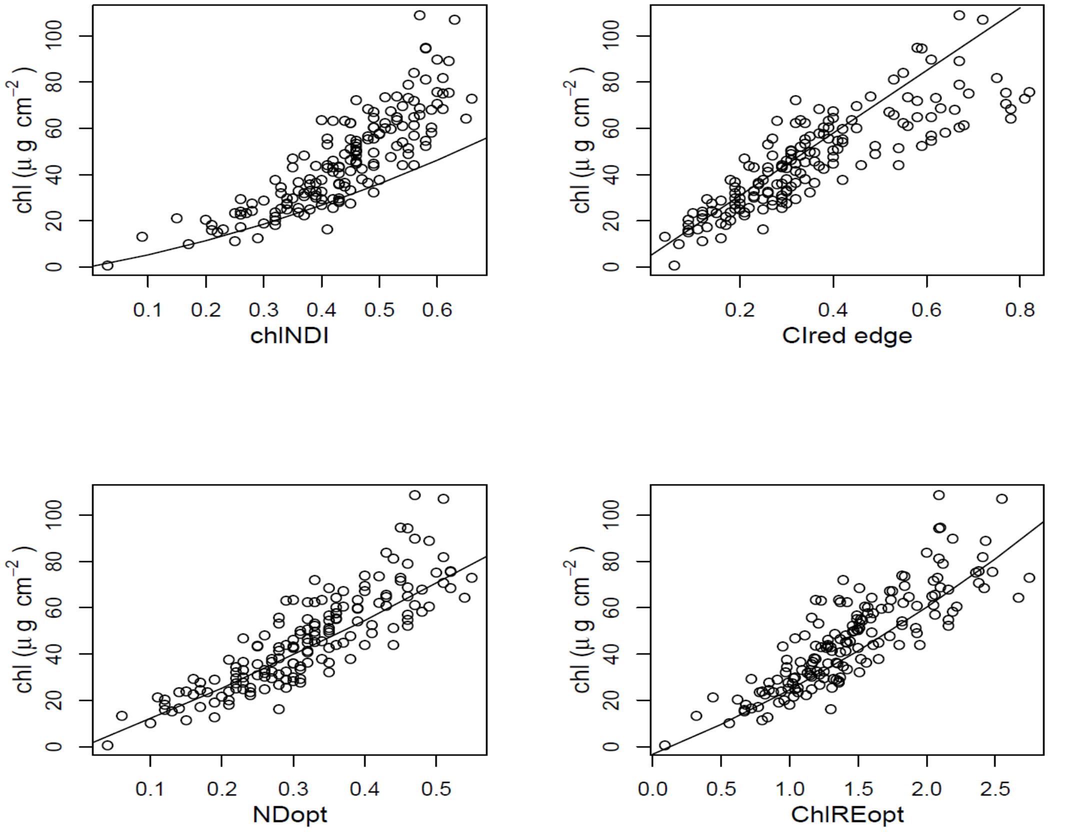
Ordinary kriging map obtained from actual SOC data (a) compared with (b) the ordinary kriging map from predicted values obtained by cubist calibration model using TASI-600 MNF data. The error map (c), expressed as difference between kriged predicted SOC (%) and kriged measured SOC (%)

Pascucci et al., 2014. Estimation of soil organic carbon from airborne hyperspectral thermal infrared data: a case study. European Journal of Soil Science

Crop vegetation estimation: leaf Chl content estimated by ASD (leafclip) field hyperspectral data

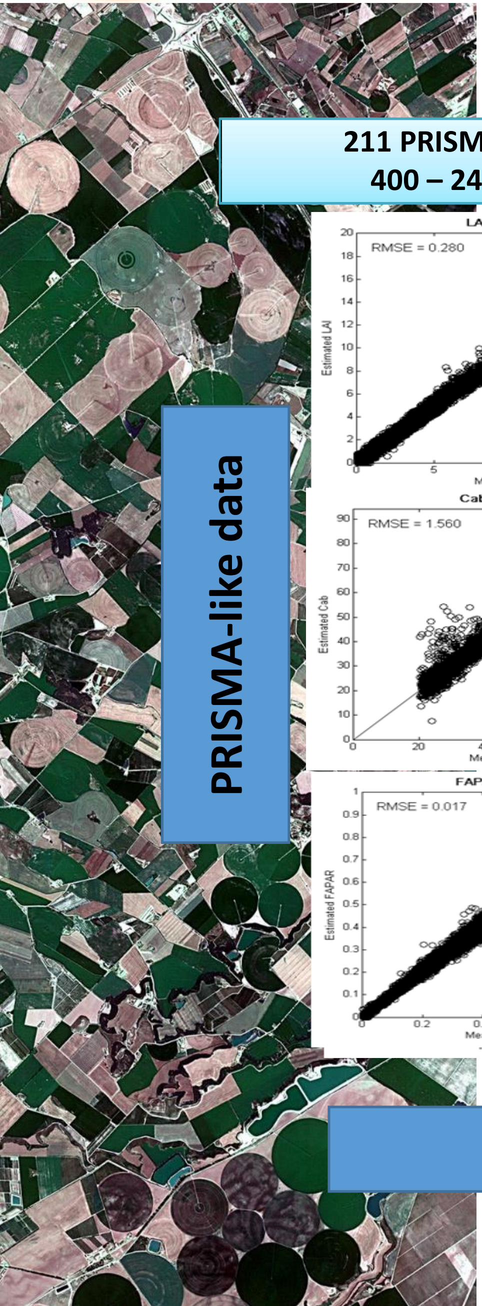
ASD leaf clip reflectance used to test the VI indexes for leaf Chl estimation validated with SPAD measurements

Indice	Formulazione
Chlorophyll Normalized Difference Index	$ChlNDI = \frac{(R_{750} - R_{705})}{(R_{750} + R_{705})}$
Green NDVI	$GreenNDVI = \frac{(R_{780-890} - R_{500-590})}{(R_{780-890} + R_{500-590})}$
Red Edge Chlorophyll Index	$CI_{red\_edge} = \frac{R_{avg(770-800)}}{R_{avg(720-730)}} - 1$
Modified Simple Ratio	$mSR = \frac{(R_{728} - R_{434})}{(R_{720} - R_{434})}$
Modified Normalized Difference	$mND = \frac{(R_{728} - R_{720})}{(R_{728} + R_{720} - 2R_{434})}$
Chlorophyll vegetation index (CVI)	$CVI = \frac{(R_{610-680} \cdot R_{780-890})}{(R_{610-680})^2}$
Chlorophyll Red Edge Optimized Index	$Chl_{RE\_opt} = \left(\frac{1}{R_{avg(680-730)}} - \frac{1}{R_{avg(780-800)}}\right) \times R_{avg(755-780)}$
Normalized Difference Optimized Index	$ND_{opt} = \frac{(R_{780} - R_{712})}{(R_{780} + R_{712})}$



Casa, R., Castaldi, F., Pascucci, S., Pignatti, S., 2014. Chlorophyll estimation in field crops: an assessment of handheld leaf meters and spectral reflectance measurements. Journal of Agricultural Science, 153, 876-890.

Agricultural components estimation through model simulations and neural network analysis

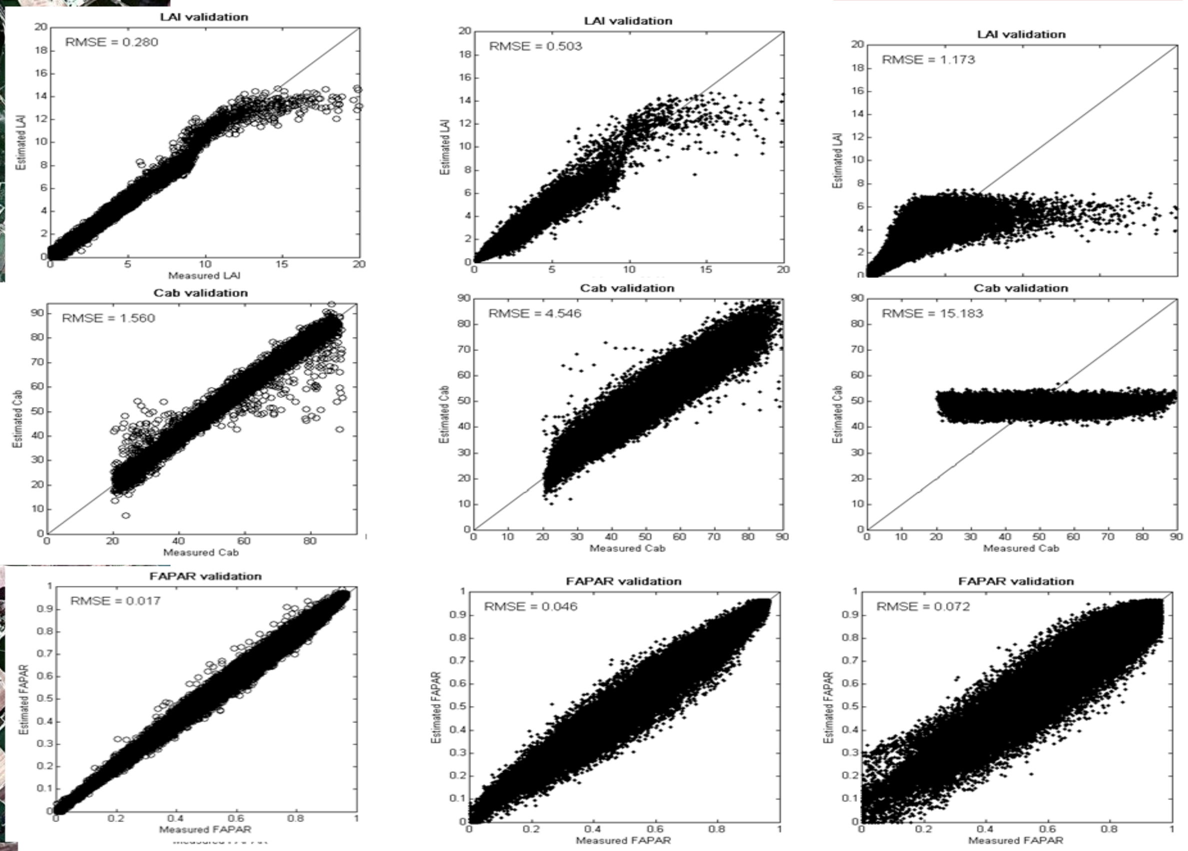


PRISMA-like data

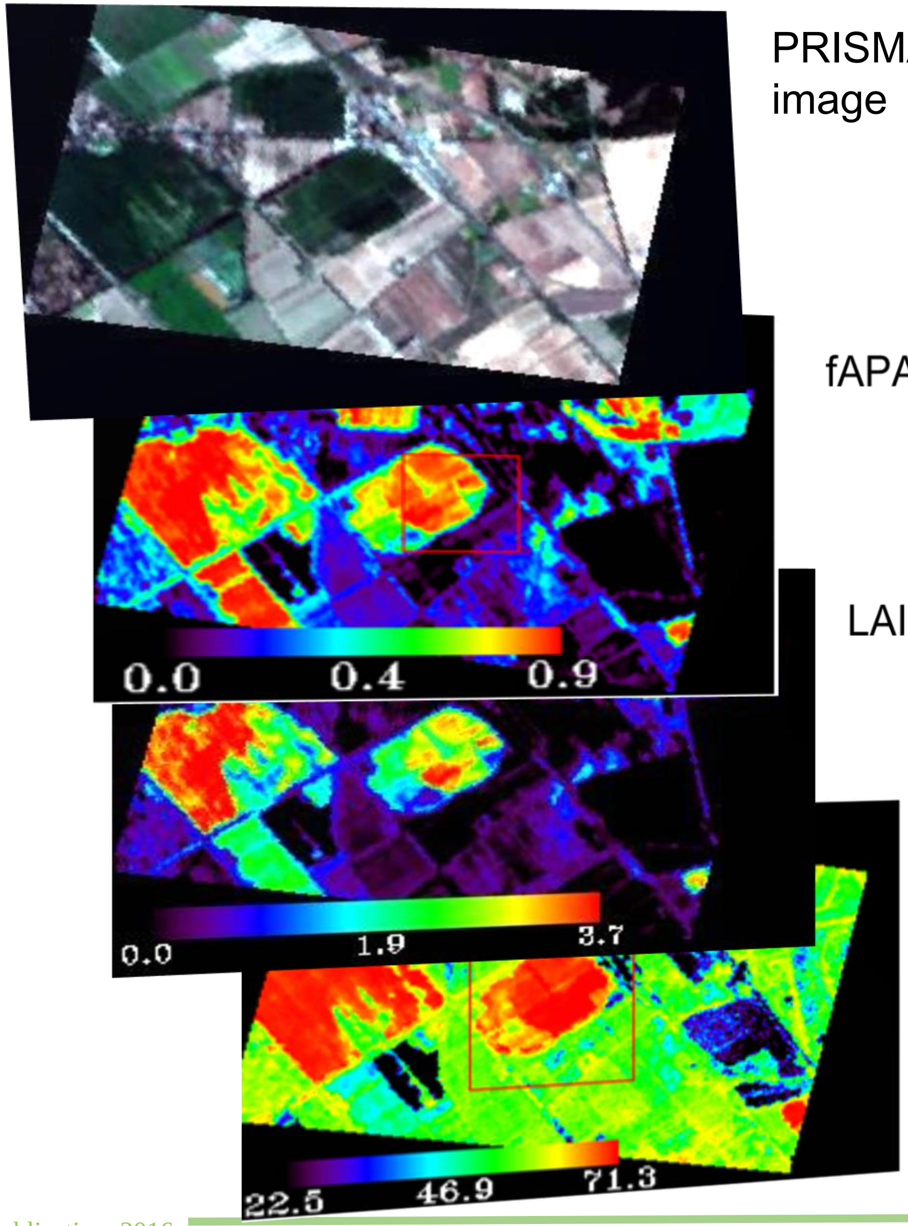
211 PRISMA bands
400 – 2400 nm

8 VI

2 PC



52.488 indipendent PROSAIL simulations
for training (cal) and ANN (val)



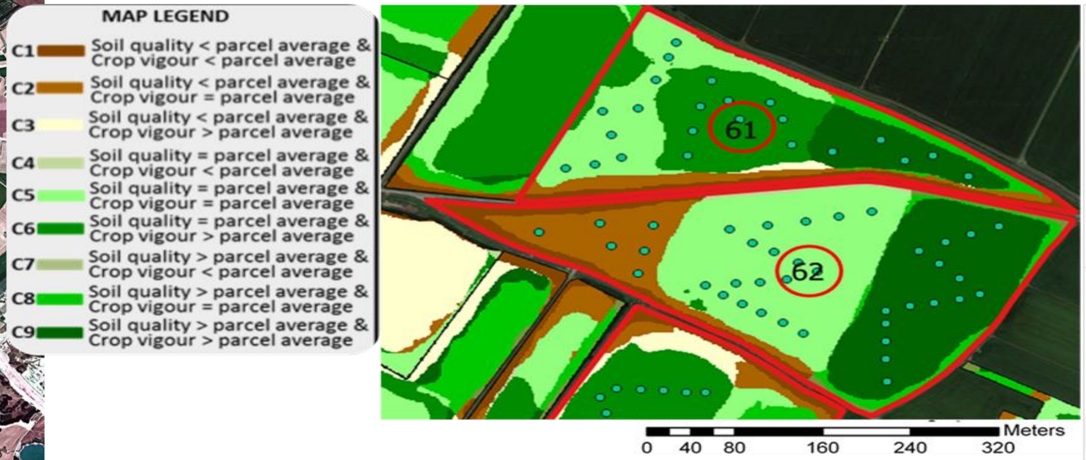
Also in: How Can Space Make a Difference for the Agriculture Sector | ANNEXES - NEREUS Publication, 2016.

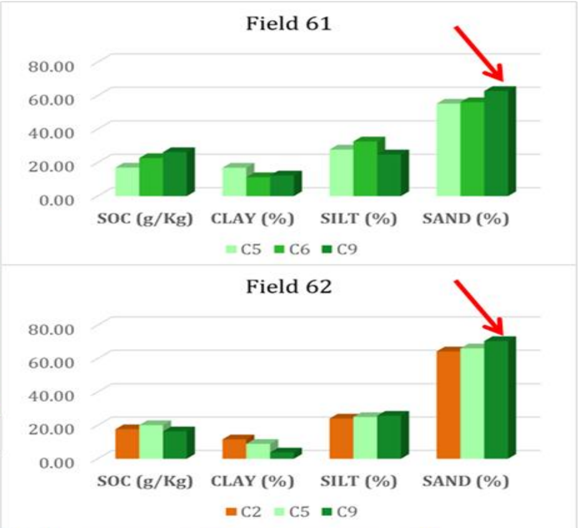
ERMES: A downstream service to support agro-production, planning and policy

FP7-SPACE-2013-1- CALL Contract N°: 606983

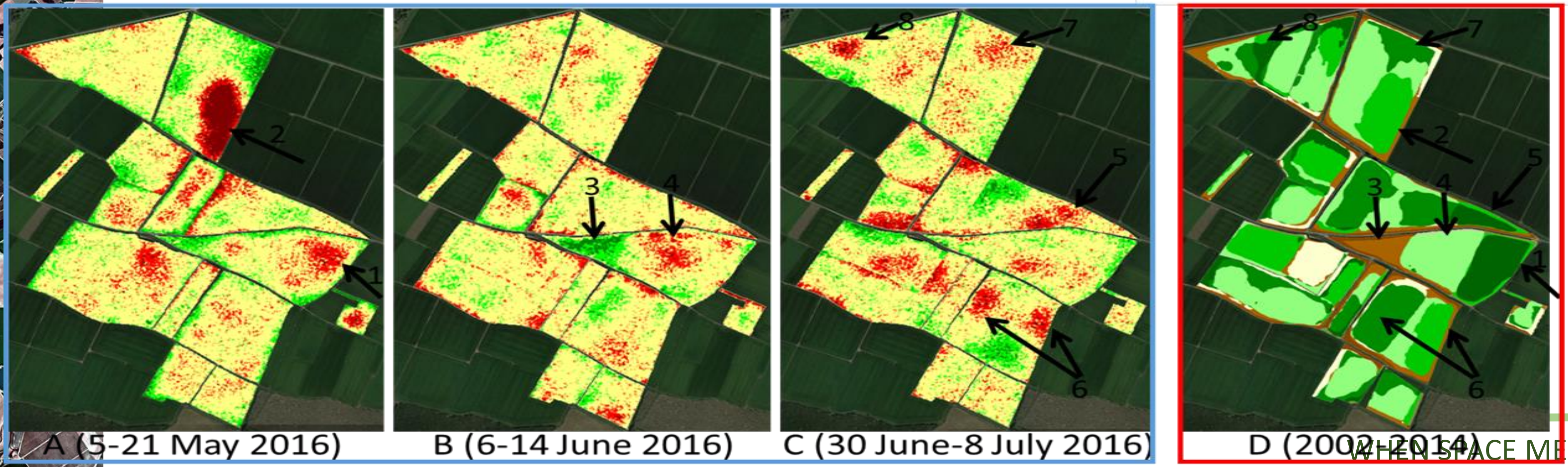
http://www.ermes-fp7space.eu/

- ERMES aims to create added-value information for the rice sector by integrating in crop models operational Copernicus core products, maps derived from SAR (Synthetic Aperture Radar) and optical Earth Observation data processing and in situ observations.
- **IMAA Activity: Soil/Biomass constant pattern map** from **SPOT** and **Landsat time-series**: winter images for bare soil properties estimation and summer images for crop biomass on rice fields





Example of a rice farm in the Lomellina rice agricultural district (Pavia)



(A,B,C) Cosmo-Skymed 2016 time variability maps (3m/pixel)

(D) Soil/Biomass constant pattern map obtained using SPOT 2002-2014 time series (5-10m/pixel)

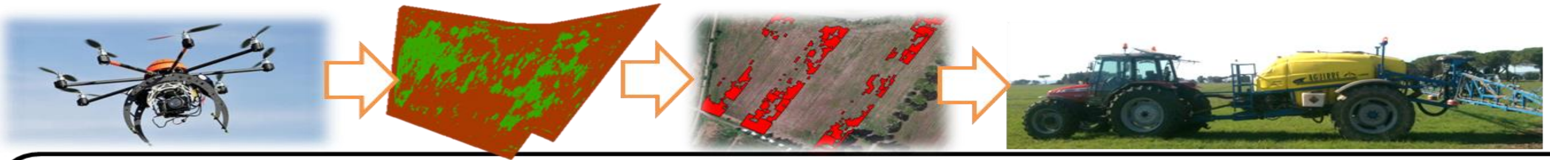
Comparison results between Optical (SPOT 5m) soil/biomass product and Radar (COSMO-SkyMed 3m) time series

UAVs for site-specific weed management (SSWM)

- UAV data provide images with a very high spatial resolution (<5 cm)
- UAVs are less expensive and they have less logistic constraints as compared to airborne platforms
- Wide commercial availability
- UAV systems offer the possibility of having more acquisitions during the crop growing season, providing higher temporal resolution data than airborne or satellite data
- Acquisitions under cloudy weather

The use of UAV data can be a very powerful tool to assist weed management based on patch spraying

UAV data should be tested in operational situations of SSWM to ensure that their use leads to effective economic and environmental benefits.



UAV → Weed map → Prescription map → Patch spraying

To reduce herbicide amount

Economic | Environmental

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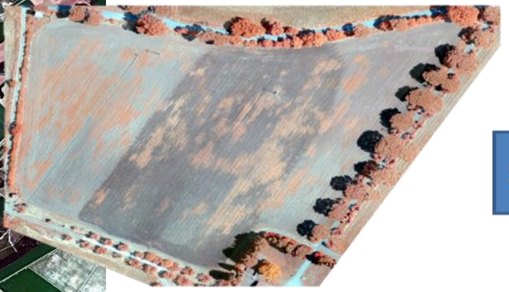
Weed maps

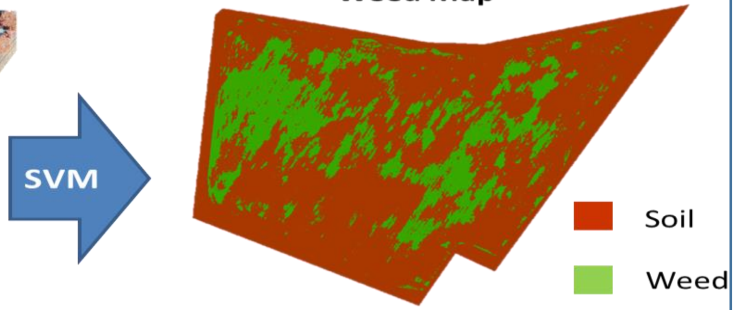
Cyperus rotundus

Malva sylvestris
Cynodon dactylon
Artemisia vulgaris
Polygonum aviculare

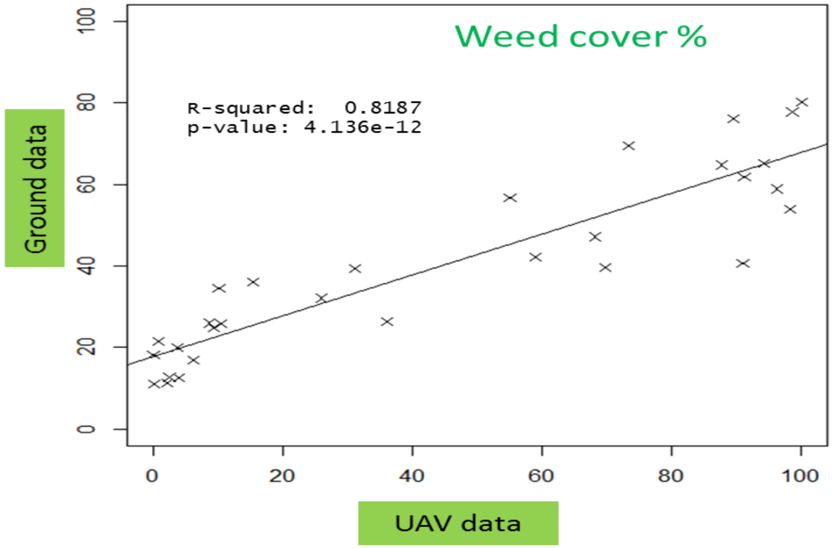
UAV image was employed to obtain a weed map of the fields using a supervised classification based on support vector machine algorithm (SVM)

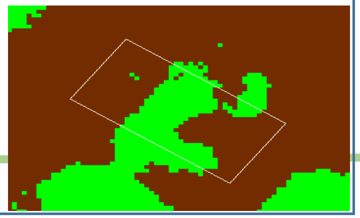
UAV image





UAV vs Ground surveys

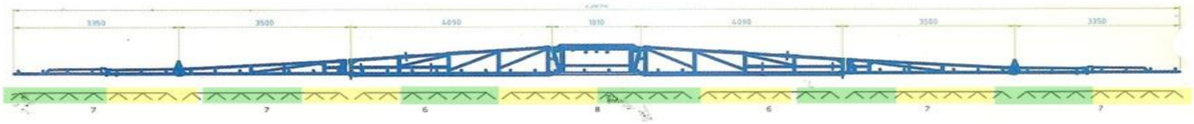




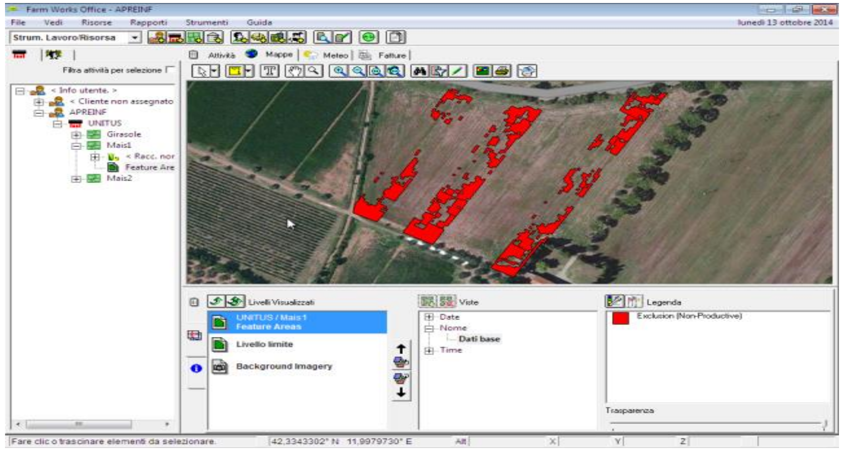
Prescription maps

Considering the good agreement between UAV and ground data, we processed the estimated weed maps in order to obtain the herbicide prescription maps, defining patches to be treated on a regular grid of 2 x 2 m.

The dimension of the grid of the prescription maps was chosen according to the length of the independent sections of the boom sprayer.



The prescription maps were uploaded onto a Trimble CFX-750 monitor on board a Massey Ferguson 4365 tractor, equipped with a Field-IQ Crop Input Control System. The system controlled the opening and closing of twelve independent sections, each of 2 m width with 4 nozzles, of a 24 m boom sprayer



The herbicide treatment was carried using a herbicide at a rate of 2 l/ha with active ingredient mesotrione and nicosulfuron. Herbicide spraying treatment was carried out only on the pixel of prescription map having weed coverage higher or equal than 10%.

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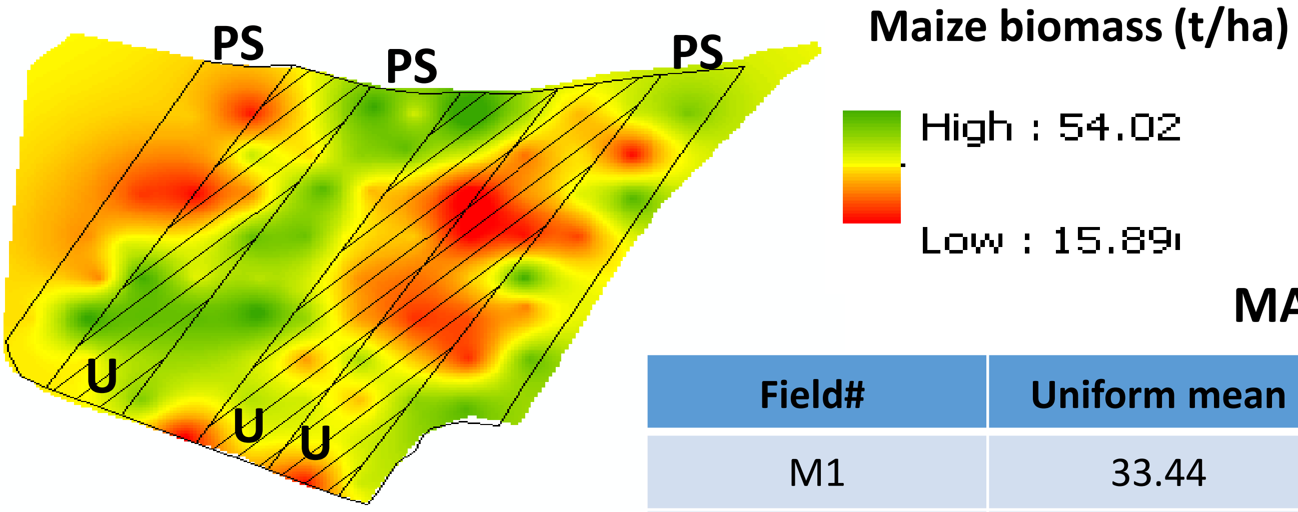
Uniform (U) vs Patch Spraying (PS)



MAIZE BIOMASS (t/ha)

Field#	Uniform mean	Patch spraying mean	Difference
M1	33.44	33.1	0.34
M2	27.15	24.95	2.2

WEED BIOMASS (t/ha)

Field#	Uniform mean	Patch spraying mean	Difference
M1	0.22	0.24	-0.02
M2	0.78	0.74	0.04

Patch spraying lead to an average reduction in the use of herbicide

54% in M1

21% in M2

MANY THANKS!

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